SYSTEM AND METHOD FOR MANAGING ELEMENTS OF A COMMUNICATION NETWORK

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention generally relates to network management techniques and, in particular, to a network management system and method for efficiently managing network elements that are utilized to transmit and/or process signals within a communication network.

RELATED ART

A conventional communication network, for example, the public switched telephone network (PSTN), often employs a large number of communication network elements for signal processing and routing. For example, when a customer subscribes for digital subscriber line (DSL) service, a network provider connects a communication device of the customer to a DSL network element, such as a DSL card, via a DSL line extending from a field office of the communication network to the customer's premises. The DSL card typically includes circuitry for controlling various attributes (*e.g.*, line speed, error correction settings, *etc.*) of the DSL line.

Other customers also may subscribe for DSL services or other types of services offered by the network service provider. To provide such services, the network service provider may extend one or more communication connections from the premises of these

other customers to the same field office. Various other network elements (*e.g.*, DSL cards, IMA cards, ATMs, *etc.*) may be employed at the field office for controlling communication across these connections. Each of the aforementioned network elements is often positioned on one or more racks or chassis within the field office. Note that typical communication networks employ a large number of field offices similar to the one described above.

Over time, the configuration of the network elements within the network may need to be changed. For example, certain network elements (*e.g.*, DSL cards) may need to be added as more customers subscribe for DSL service. When a network element is added, it should be initially provisioned based on the desired attributes of the communication line being serviced by the network element. Later, the same network element may be utilized to service a different customer requiring a change to the configuration of the network element. As an example, the new customer may be located a different distance from the field office of the network element, and it may be desirable, therefore, to change the line speed of the communication line serviced by the network element. Note that there are various other reasons why it may be desirable to control or change the configuration of a network element. Such reasons are well known in the art and will not be described in significant detail herein.

The process of monitoring the performance and/or changing the configuration of network elements can be a tedious and time consuming task due, in part, to the large number of network elements usually employed in implementing a conventional network. Previously, a technician would travel to various field offices to monitor and/or change the configurations of various network elements. However, the cost of utilizing such

techniques to monitor and control the configurations of network elements increased dramatically as networks rapidly grew to service more customers.

To facilitate the monitoring and controlling of network elements, element management systems have been developed. An element management system (EMS) is essentially a server system that is communicatively coupled to the various network elements employed within a network. The EMS is also coupled to various computer terminals, often referred to as "clients."

Moreover, a user located at a client may submit a request for monitoring the operation of a particular network element. The client communicates the request to the EMS, and in response, the EMS gathers the requested information and provides the requested information to the client. If the user desires to change the configuration of the network element, the user may submit another request that causes the EMS to change the configuration of the network element as desired. Thus, the EMS enables a user to remotely monitor and control various network elements without having to travel to the different field offices where the network elements reside.

In order to enable users to monitor and control network elements, the clients typically include software, such as JAVA, for example, that define graphical user interfaces for controlling the various types of network elements. For example, a first type of network element (*e.g.*, an ADSL card) may control attributes different than the attributes controlled by a second type of network element (*e.g.*, an IMA card). In such a case, software defining a graphical user interface (GUI) suitable for displaying and changing the attributes of the first type of network element and software defining a GUI suitable for displaying and changing the attributes of the second type of network element

may be downloaded into the clients. A topology of the network may be displayed via the client, and the user may select one of the network elements of the topology. The GUI associated with the type of selected network element is then displayed and filled with attribute data that is gathered by the EMS and that pertains to the selected network element. Note that a selection of a different type of network element invokes a different GUI suitable for monitoring and controlling attributes for the different type of network element.

Often, it is desirable to update GUIs utilized to monitor and change network element attributes. For example, new types of network elements are often added to the network as new services become available. In order to enable the clients to monitor and control the new types of network interfaces, it is often necessary or desirable to download different types of GUIs into the clients. In another example, it may be desirable to change an existing GUI to accommodate changes to the network elements serviced by the existing GUI. The process of updating the GUIs can be a burdensome and time consuming task. Indeed, even the task of tracking which clients have been suitably updated and which clients need to be updated can be difficult and burdensome, particularly when a large number of clients are employed.

Furthermore, when multiple clients are employed within a network, it is sometimes possible for one client to display an obsolete set of attribute data for one or more network elements. In this regard, after one client has polled a particular network element to discover the element's attributes, another client may change the configuration of the element. Thus, once the change to the element's configuration occurs, the attribute data received by the one client no longer accurately reflects the state of the particular

network element. As a result, the one client may indicate an erroneous or obsolete state of the changed element.

In addition, as the number of network elements and/or clients within a network grows, the amount of data communicated by the network's EMS typically increases. This can put a significant communication burden on the EMS and can cause some communication delays.

Thus, while the introduction of EMSs has greatly facilitated the process of monitoring and controlling network elements, current EMSs suffer from various drawbacks that generally decrease the overall efficiency and/or effectiveness of the EMSs.

SUMMARY OF THE INVENTION

Generally, the present invention provides a system and method for managing elements of a communication network.

A system in accordance with one embodiment of the present invention utilizes a plurality of clients, a plurality of network elements, and an element management system (EMS). The clients and the network elements are interfaced with the EMS. The EMS is configured to track which of the network elements are of interest to the clients and to automatically monitor the network elements based on which of the network elements are determined, by the EMS, to be of interest to the clients. The EMS is further configured to provide the clients with information indicative of the monitored elements.

In accordance with another feature of the present invention, an EMS may be configured to store graphical user interface (GUI) code that can be utilized to provide a

GUI for monitoring and/or changing a network element. The EMS may provide the GUI code to the clients on demand and may enable a user to update the GUI code stored at the EMS. As a result, a single update to the GUI code at the EMS may effectively update the GUI code utilized by any or all of the clients.

The present invention can also be viewed as providing a method for managing elements of a communication network. The method can be broadly conceptualized by the following steps: tracking which of the network elements are of interest to a plurality of clients; automatically monitoring the network elements based on the tracking step; and providing the clients with information indicative of the monitored elements based on the monitoring step.

Various features and advantages of the present invention will become apparent to one skilled in the art upon examination of the following detailed description, when read in conjunction with the accompanying drawings. It is intended that all such features and advantages be included herein within the scope of the present invention and protected by the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be better understood with reference to the following drawings. The elements of the drawings are not necessarily to scale relative to each other, emphasis instead being placed upon clearly illustrating the principles of the invention. Furthermore, like reference numerals designate corresponding parts throughout the several views.

FIG. 1 is a block diagram illustrating a conventional communication system.

FIG. 2 is a block diagram illustrating a conventional element management system that may be utilized to monitor and/or control network elements depicted in FIG. 1.

FIG. 3 is a block diagram illustrating an element management system that may be utilized to monitor and/or control network elements depicted in FIG. 1 in accordance with a preferred embodiment of the present invention.

FIG. 4 is a block diagram illustrating a more detailed view of the element management system depicted in FIG. 3.

FIG. 5 is a block diagram illustrating a more detailed view of a client depicted in FIG. 3.

FIG. 6 is a block diagram illustrating a more detailed view of a system controller depicted in FIG. 4.

FIG. 7 is a flow chart illustrating a preferred architecture and functionality of a communication manager depicted in FIG. 6 for each message received by the communication manager.

FIG. 8 is a flow chart illustrating a preferred architecture and functionality of a server depicted in FIG. 6.

FIG. 9 is a flow chart illustrating a preferred architecture and functionality of a status manager depicted in FIG. 6.

DETAILED DESCRIPTION OF THE INVENTION

The present invention generally pertains to an element management system (EMS) for the telecommunication industry. The EMS of the present invention services one or more clients by providing the clients with information pertaining to selected network

elements and by enabling the clients to change the configuration of selected network elements. The network elements reside in a communication network (*e.g.*, the public switched telephone network (PSTN), the Internet, *etc.*) and control various communication attributes of the network.

FIG. 1 depicts a conventional communication system **12**. As shown by **FIG. 1**, the system **12** includes a communication network **15** that is communicatively coupled to a plurality of communication devices **17**. The communication devices **17** may communicate to one another over the network **15** via techniques well known in the art. Each of the communication devices **17** is usually serviced by one or more network elements **21** residing within the network **15**. A first set **24** of network elements **21** resides within a first field office and services communication devices **17** located within a close proximity of the first field office. Furthermore, a second set **25** of network elements **21** resides within a second field office and services communication devices **17** located within a close proximity of the second field office. Note that other numbers of field offices, communication devices **17**, and network elements **21** are possible. Indeed, most conventional communication networks **15** typically employ millions of network elements **21** thereby enabling communication between millions of communication devices **17**.

An EMS **28** is typically employed to enable efficient monitoring and controlling of the network elements **21**. As shown by **FIG. 2**, the EMS **28** is usually coupled to a plurality of clients **31** that may be located remotely from the EMS **28** and/or the network elements **21**. Each client **31** usually includes various sets of graphical user interface (GUI) code **33** for displaying various GUIs to a user of the client **31**. Network elements **21** of different types usually monitor and control different communication attributes, and

each set of GUI code **33** defines a different GUI, which is usually specifically designed for a certain type of network element **21**. For example, a first GUI may be designed for a network element **21** of a first type (*e.g.*, a DSL card), and a second GUI may be designed for a network element **21** of another type (*e.g.*, an IMA card).

Moreover, when the user of a client **31** selects a particular network element **21** for monitoring and/or control, the client **31** invokes the set of GUI code **33** that defines a GUI corresponding to selected element's type. The invoked code **33** displays a GUI compatible with the selected network element **21**, and the user, via the displayed GUI, may submit commands for changing the configuration of the selected network element **21**, as will be described in more detail hereafter.

Typically, when a set of GUI code **33** is invoked, the invoked set of GUI code **33** not only displays a GUI, as described above, but also, either periodically or on demand, transmits a status request to the EMS **28**. The status request identifies the network element **21** selected by the user of the client **31**, and in response to the status request, the EMS **28** gathers information pertaining to the status or operation of the selected network element **21**. In this regard, the EMS **28** is communicatively coupled to the selected network element **21** and reads the requested information from the selected network interface **21**. Communication between the EMS **28** and the network elements **21** is typically achieved via transmission control protocol/internet protocol (TCP/IP) and simple network management protocol (SNMP).

After reading the requested information, the EMS **28** transmits the requested information to the requesting client **31**. Note that communication between the EMS **28** and clients **31** is also typically achieved via TCP/IP. The set of GUI code **33** that

originally submitted the status request displays the requested data via the GUI displayed by the invoked code **33**. Thus, the user of the client **31** is able to determine and monitor the status of the selected network element **21**.

At times, the user of the client **31** may desire to change the configuration of the selected network element **21**. For example, the user may desire to change the line speed of a communication line being serviced by the selected network element **21**. The GUI displayed to the user usually allows the user to submit commands for changing the configuration of the selected network element **21**. When such a command is submitted, the GUI code **33** transmits the command to the EMS **28**, which then changes the configuration of the selected network element **21** in response to the command from the client **31**.

For example, in the case where the user desires to change the line speed of the selected network element **21**, the network element **21** may be configured to control its line speed based on a control value stored in a control register (not shown) residing within the network element **21**. In this example, the EMS **28** may be configured to overwrite the foregoing control value with a new value based on the command received from the client **31**. In other examples, other techniques may be employed by the EMS **28** in servicing other types of configuration change commands received from the clients **31**.

The system **12** shown by **FIGS. 1** and **2** suffers from a variety of drawbacks. For example, changes in the GUI code **33** of each of the clients **31** may be required to accommodate changes in the network elements **21**. The process of updating the GUI code **33** in each of the clients **31** and of tracking the updates made to the GUI code **33** of

the different clients **31** can be burdensome and time consuming, particularly as the number of clients **31** increases.

Furthermore, increases in the number of clients **31** generally increase the amount of communication between the EMS **28** and the clients **31**. More particularly, more clients **31** may result in a higher number of status requests and/or configuration change commands being communicated to the EMS **28**. Moreover, such increased communication between the EMS **28** and the clients **31** increases the EMS's processing burden and may cause undesirable communication delays.

In addition, when a plurality of clients **31** are monitoring the same network element **21**, it is possible for some of the clients **31** to display obsolete status information. In this regard, one of the clients **31** may submit a command for changing the configuration of the monitored network element **21**. The status information being displayed by the other clients **31** may become obsolete once the configuration change occurs. More specifically, until the status information displayed by the other clients **31** is refreshed, the displayed status information exhibits the state of the network element **21** as it existed before the occurrence of the configuration change. As a result, users of the other clients **31** may be viewing inaccurate or obsolete status information.

The present invention overcomes many of the shortcomings and inadequacies discussed hereinabove. An EMS **50** in accordance with a preferred embodiment of the present invention is depicted by **FIG. 3**. Similar to the conventional EMS **28** of **FIG. 2**, the EMS **50** of the present invention is communicatively coupled to one or more network elements **21** and one or more clients **52**. As shown by **FIG. 4**, the EMS **50** preferably includes a system controller **55** that controls the operation of the EMS **50**, as will be

described in more detail hereafter. The system controller **55** can be implemented in software, hardware, or a combination thereof. In the preferred embodiment, as illustrated by way of example in **FIG. 4**, the system controller **55** of the present invention, along with its associated methodology, is implemented in software and stored in memory **58** of the EMS **50**.

Note that the system controller **55**, when implemented in software, can be stored and transported on any computer-readable medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch and execute instructions. In the context of this document, a "computer-readable medium" can be any means that can contain, store, communicate, propagate, or transport a program for use by or in connection with the instruction execution system, apparatus, or device. The computer-readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, and a portable compact disc read-only memory (CDROM). Note that the computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via for instance optical scanning of the paper or other medium, then compiled, interpreted or otherwise processed in a suitable manner if necessary, and then stored in a computer memory. As

an example, the system controller **55** may be magnetically stored and transported on a conventional portable computer diskette.

The preferred embodiment of the EMS **50** of **FIG. 4** comprises one or more conventional processing elements **61**, such as a central processing unit (CPU), for example, that communicate to and drive the other elements within the EMS **50** via a local interface **63**, which can include one or more buses. Furthermore, an input device **65**, for example, a keyboard or a mouse, can be used to input data from a user of the EMS **50**, and an output device **67**, for example, a screen display or a printer, can be used to output data to the user. The EMS **50** preferably includes a network element interface **69** for communicating with the network elements **21** and a client interface **71** for communicating with the clients **52**.

As shown by **FIG. 4**, various sets of GUI code **33** are maintained within the EMS **50**. The GUI code sets, as described hereinabove, define different GUIs for different types of network elements **21**. The GUIs allow users to exchange information with the clients **52** for monitoring the status of the network elements **21** and/or changing the configuration of the network elements **21**. Also maintained within the EMS **50** is element status data **74** and network topology data **75**. The network topology data **74** defines a topology of the network elements **21** and indicates the status of each of the network elements **21**. The GUI code **33**, the element status data **74**, and the network topology data **75** will be described in more detail hereafter.

As shown by **FIG. 5**, each of the clients **52** includes a client controller **81** that generally controls the operation of the client **52**. The client controller **81** can be implemented in software, hardware, or a combination thereof. In the preferred embodiment, as illustrated by way of example in **FIG. 5**, the client controller **81**, along with its associated

methodology, is implemented in software and stored in the client's memory **84**. When implemented in software, the client controller **81** can be stored and transported on any computer-readable medium.

The client **52** shown by **FIG. 5** also comprises one or more conventional processing elements **87**, such as a central processing unit (CPU), for example, that communicate to and drive the other elements within the client **52** via a local interface **89**, which can include one or more buses. Furthermore, an input device **93**, for example, a keyboard or a mouse, can be used to input data from a user of the client **52**, and an output device **96**, for example, a screen display, can be used to output data to the user. The client **52** preferably includes an EMS interface **99** for communicating with the EMS **50** **(FIG. 3)**.

When the user of the client **52** desires to monitor the status of a network element **21** and/or to control a configuration of a network element **21**, the user, via input device **93**, submits an input for establishing a communication session between the client **52** and the EMS **50**. In response, the client **52**, via EMS interface **99**, communicates to the EMS **50** a message indicating that the client **52** is interested in utilizing the services of the EMS **50**. The system controller **55** of the EMS **50** then retrieves topology data **75**, and the system controller **55** also retrieves a set of GUI code **33** for displaying the topology data **75** and for allowing the user to select one of the network elements **21** within the topology defined by the topology data **75**. The EMS **50** communicates the retrieved data to the client **52**, which then stores and invokes the received GUI code **33** thereby displaying a topology of the network interfaces **21** to the user via the output device **96**.

From the displayed topology, the user selects a network element **21**. The GUI code **33** for displaying the topology then communicates, to the EMS **50**, a message (referred to

hereafter as a "display request") identifying the network element **21** selected by the user. In response, the system controller **55** retrieves the set of GUI code **33** pertaining to the type of selected network element **21**, and the system controller **55** retrieves status data **74** indicative of the current operational state of the selected network element **21**. The system controller **55**, via client interface **71**, transmits the retrieved set of GUI code **33** and status data **74** to the client **52**.

Upon receiving the GUI code **33**, the client **52** stores and invokes the received GUI code **33** such that a GUI **101** associated with the selected network element **21** is displayed to the user via the output device **96**. The displayed GUI **101** may include the status data **74** that is indicative of the present state of the selected network element **21** and may include options for changing the configuration of the selected network element **21**. Thus, the user can view the GUI **101** to analyze the present state of the selected network element **21**, and if desired, the user may select one of the options for changing the state of the selected network element **21**.

If the user selects an option to change the configuration of the selected network element **21**, the GUI code **33** defining the displayed GUI **101** transmits, via EMS interface **99**, a command for changing the selected element's configuration. In response, the system controller **55** changes the configuration of the selected network element **21** as instructed. The system controller **55** also updates the element status data **74**, as appropriate, to account for the changed configuration. For example, if the user requested a change to the selected element's line speed, then the system controller **55** updates the data **74** such that it indicates the line speed, as changed by the system controller **55**, for the selected network element **21**.

Also, the system controller **55** automatically transmits, to each of the other clients **52** interested in the selected element **21**, data (referred to hereafter as "element update data") indicative of the configuration change. A client **52** is "interested" in the selected element **21** if the client **52** is presently being used to monitor or analyze the state of the selected element **21**. Moreover, each interested client **52** may be displaying information indicative of the status of the selected element **21**, and each such client **52** updates this displayed information based on the element update data received from the system controller **55** such that the displayed information accounts for the aforementioned configuration change. Thus, the status information displayed by each client **52** for a particular element **21** is preferably updated, in real-time, when any one of the clients **52** changes the configuration of the particular element **21**.

Note that the system controller **55** can be configured to transmit the element update data to each client **52** communicatively coupled to the EMS **50**. However, such an embodiment needlessly transmits the element update data to clients **52** that are not presently interested in the changed network element **21**. A more efficient approach is to transmit the element update data only to the clients **52** interested in the changed element **21**. To enable such an embodiment, the system controller **55** preferably tracks which clients **52** are interested in which network elements **21**.

In the preferred embodiment, the system controller **55** tracks the interest of the clients **52** by tracking the use of the GUI code **33**, and the system controller **55** preferably maintains client profile data **105** that is indicative of which clients **52** are interested in which elements **21**. In this regard, as described above, the system controller **55** is notified, via a "display request," when a user of a client **52** desires to monitor the status of a selected

element **21** or to change the configuration of the selected element **21**. Upon receiving such a notification from a particular client **52**, the system controller **55** preferably updates the client profile data **105** such that the data **105** indicates that the particular client **52** is interested in the selected element **21**. Once a user no longer desires to monitor or control the particular element **21**, the user can close the GUI **101** being used to monitor and/or control the particular element **21**. The closing of the foregoing GUI **101** indicates that the client **52** is no longer interested in receiving status information pertaining to the particular element **21**. Moreover, when the user closes the GUI **101**, the client **52** preferably notifies the system controller **55** of the EMS **50**. In response, the system controller **55** updates the client profile data **105** to indicate that the client **52** is not interested in the particular element **21**.

Therefore, when the system controller **55** determines that the configuration or status of a network element **21** has changed, the system controller **55** can consult the client profile data **105** to determine which clients **52** are interested in the change. Based on the client profile data **105**, the system controller **55** can then transmit data indicative of the change only to the clients **52** interested in the change. By implementing the foregoing techniques, the integrity of the data displayed by the clients **52** is protected. More specifically, when any one of the clients **21** changes the configuration or state of a network element **21**, all of the other clients **52** interested in the changed network element **21** should be immediately and automatically notified.

It should be noted that when a user closes a GUI **101**, the client **52** preferably discards the set of GUI code **33** defining the closed GUI **101**. Furthermore, each time a new GUI **101** is to be displayed by a client **52**, the GUI code **33** defining the new GUI **101** is

preferably downloaded to the client **52** from the EMS **50**, as described hereinabove. By downloading GUI code **33** on demand in this way, the process of updating the GUI code **33** to accommodate for changes in the network elements **52** is facilitated. In this regard, when a change to a set of GUI code **33** is to be made or when a set of GUI code **33** is to be added, a user can simply update the GUI code **33** residing at the EMS **50**. Since the clients **52** request a download of GUI code **33** each time a new GUI **101** is opened, future openings of GUIs **101** by the clients **52** will be based on the updated GUI code **33** residing at the EMS **50**. Thus, updating the GUI code **33** at the EMS **50** has the effect of updating the GUI code **33** for all of the clients **52**.

Furthermore, as described hereinabove, the system controller **55** may be aware of which clients **52** are interested in which network elements **21**. When an update to a set of GUI code **33** at the EMS **50** occurs, the system controller **55** may be configured to transmit the set of updated GUI code **33** to each client **52** that is presently utilizing or running the same set of code **33**. The clients **52** that would be utilizing or running the same set of code **33** are the clients **52** interested in a network element **21** of the type associated with the updated code **33**. For example, if an update to the set of code **33** defining a GUI for DSL cards occurs at the EMS **50**, each client **52** interested in one of the network's DSL cards preferably receives the updated code **33**. Moreover, each client **52** receiving the updated code **33** preferably discards its present version of the code **33** (which has yet to be updated) and begins utilizing or running the updated set of code **33** received from the EMS **50**. Accordingly, each client **52** utilizing or running a set of code **33** that is updated at the EMS **52** is automatically and immediately notified of the update and enabled to run the updated version of the code **33** in lieu of the obsolete version residing at the client **52**.

Note that, by maintaining the GUI code **33** at the EMS **50** and by downloading code **33** from the EMS **50** when a new GUI **101** is to be opened, it is not necessary for a user to manually update each client **52** or to keep track of which clients **52** have received updated code **33**. A user simply updates the code **33** at the EMS **50**, and the system controller **55** of the EMS **55** automatically provides each client **52** with the updated code **33**, as needed, thereby making updates to the code **33** easier and less time consuming.

In the preferred embodiment, the EMS **50** is configured to monitor the status of each network element **21** that is of interest to any of the clients **52**. In this regard, the system controller **55** periodically investigates the status of each such network element **21** and updates the element status data **74** when the status of any monitored element **21** changes. Thus, the element status data **74** should reflect the present status of each element **21** of interest to any client **52**.

Furthermore, when the system controller **55** detects a change to the status of one of the monitored elements **21**, the system controller **55** not only updates the element status data **74**, but the system controller **55** also automatically transmits data indicative of the changed status (*i.e.*, element update data) to each client **52** interested in the changed element **21**. Each client **52** interested in the changed element **21** may then update its display of the element's status information such that the user of the client **52** views up-to-date status information for the foregoing element **21**. In other words, the users of clients **52** are able to see changes in the status of monitored elements **21** in real-time.

By monitoring the status of the elements **21** via the system controller **55** and automatically transmitting element update data to the clients **52** as needed, it is not necessary for the clients **52** to transmit status requests to the EMS **50**. Thus, implementing

the foregoing techniques helps to reduce the amount of communication that occurs between the clients **52** and the EMS **50**. Furthermore, with the conventional EMS **28**, if more than one client **31** is interested in the same network element **21**, each such client **31** polls the network element **21**. However, with the EMS **50** of the preferred embodiment of the present invention, a particular network element **21** is polled only by the system controller **55**, even if multiple clients **52** are interested in the particular element **21**. Thus, implementing the foregoing techniques also helps to reduce the amount of communication that occurs between the EMS **50** and the network elements **21**.

In the preferred embodiment, the system controller **55** is configured to monitor the network elements **21** based on which elements **21** are of interest to any of the clients **52**. In this regard, monitoring network elements **21** that are not of interest to any of the clients **52** is unnecessary and wasteful. Thus, the system controller **55** can consult the client profile data **105** and determine which of the network elements **21** are of interest to one or more of the clients **52**. The system controller **55** then polls only the network elements **21** that are of interest to one or more clients **52**. Note that which network elements **21** are of interest to one or more clients **52** may change over time, and the system controller **55** is preferably configured to detect such changes and to appropriately change which network elements **21** are monitored by the system controller **55**.

In addition, as described hereinabove, the system controller **55** detects when a client **52** terminates its interest in a particular network element **21** by detecting when the client **52** closes the GUI **101** that enables the client **52** to monitor the status of the element **21** and/or to control the configuration of the element **21**. However, in some instances, a client **52** may fail to inform the system controller **55** when the client **52** closes a GUI **101** and, therefore,

when the client's interest in the element **21** associated with the closed GUI **101** terminates. For example, the communication between the client **52** and the system controller **55** may be interrupted before the client **52** is able to transmit a message indicating that the GUI **101** has been closed. Thus, the client profile data **105** may erroneously indicate that a client **52** is interested in a particular element **21** when, in fact, the client **52** is no longer interested in the particular element **21**. Accordingly, the system controller **55** may be configured to actively check whether or not clients **52** are still interested in elements **21** being monitored by the system controller **55**.

In this regard, to actively check whether any client **52** is interested in a particular network element **21**, the system controller **55** may periodically "ping" each client **52** with a message that induces each client **52** interested in the particular network element **21** to reply. If the network controller **55** receives a reply message, then the controller **55** is aware that the particular element **21** is presently of interest to the client **52** that transmitted the reply message. In such a case, the system controller **55** continues to monitor the particular network element **21**. However, if the network controller **55** fails to receive a reply message after a reasonable time-out period, then the network controller **55** may determine that no clients **52** are interested in the particular network element **21**. In such a case, the system controller **55** preferably terminates its monitoring of the particular network element **21** until the system controller **55** later determines that at least one client **52** has become interested in the particular network element **21**. Note that the client profile data **105** may be updated, if desired, based on which clients **52** respond to the "pings" transmitted by the system controller **55**.

It should be noted that in the preferred embodiment, as shown by **FIG. 6**, the system controller **55** is implemented via separate modules: a status manager **115**, a server **117**, and a communication manager **119**. Each of the modules may be separately and concurrently executed via the one or more processing elements **61** (**FIG. 4**). The status manager **115** is responsible for monitoring the network elements **21** and for updating the element status data **74** based on the status manager's monitoring of the network elements **21**. Note that the status manager **115** preferably utilizes TCP/IP and SNMP protocols for communicating with the network elements **21**. Furthermore, the status manager **115** detects changes in the status of the monitored elements **21** and informs the server **117** when the status manager **115** detects such a change.

The communication manager **119** is responsible for controlling the communication between the EMS **50** and the clients **52** and for maintaining the client profile data **105**. The communication manager **119** preferably utilizes TCP/IP protocol for communicating with the clients **52** and is preferably implemented as a JAVA messaging system (JMS). When data is to be transmitted to one or more clients **52**, the server **117** passes a transmit request that includes the foregoing data to the communication manager **119**. The communication manager **119** is then responsible for communicating the data to the appropriate clients **52**. Furthermore, messages received from the clients **52** are preferably passed to the server **117** by the communication manager **119**. Note that messages to be transmitted to the clients **52** may be buffered by the communication manger **119** until such messages can be transmitted by the communication manager **119**, and messages received from the clients **52** may be buffered by the communication manager **119** until the server **117** is ready to process the messages.

The server **117** is preferably configured to implement the remainder of the functionality described hereinabove for the system controller **55**. In particular, the server **117** is configured to service configuration changes requested by the clients **52** and to provide the appropriate GUI code **33** when a client **52** requests the opening of a new GUI **101**. Note that to enable the GUI code **33** to be easily updated by users of the EMS **50**, the GUI code **33** may be stored in a database, as shown by **FIG. 6**. In addition, when the status manager **115** notifies the server **117** of a detected change in the status of a monitored network element **21**, the server **117** is configured to submit a transmission request to the communication manager **119**, which notifies the interested clients **52** of the change in response to the transmission request.

The configuration of **FIG. 6** has the advantage of allocating the burdensome tasks of monitoring the network elements **21**, which typically number in the hundreds of thousands or in the millions, and of communicating with the clients **52** to separate modules essentially dedicated for performing the foregoing functions, respectively. Thus, the server **117** is not burdened with the time consuming tasks of managing communication with the elements **21** and the clients **52** and can, therefore, perform the other functionality of the system controller **55** in a timely manner. However, it should be noted that the configuration shown by **FIG. 6** is not a necessary feature of the present invention, and other configurations of the system controller **55** are possible without departing from the principles of the present invention.

It should be noted that the present invention has been described as utilizing a GUI **101** to interface data with a user of a client **52**. However, utilization of GUIs **101** and GUI code **33** is not a necessary feature. In this regard, other known data interfacing techniques and mechanisms may be employed to interface data with the users of the clients **52**.

OPERATION

The preferred use and operation of the EMS **50** and associated methodology are described hereafter.

For illustrative purposes, assume that a user would like to view the status of a particular network element **21**. The user, via the input device **93** of one of the clients **52**, referred to hereafter as "user client **52**," submits one or more inputs identifying the particular element **21** of interest. In response, the client **52** transmits a display request identifying the particular element **21** to the EMS **50**. The communication manager **119** (**FIG. 6**) receives the request and updates the client profile data **105** to indicate that the user client **52** is interested in the particular network element **21**, as shown by blocks **131** and **133** of **FIG. 7**. The communication manager **119** then notifies the server **117** of the display request, as shown by block **135**.

In response, the server **117** retrieves the set of GUI code **33** that is associated with the particular element's type, as shown by blocks **142** and **145** of **FIG. 8**. In block **145**, the server **117** also retrieves status data **74** indicative of the current status of the particular element **21**. The server **117** then includes the retrieved data in a transmission request and passes the transmission request to the communication manager **119** in block **147**.

In response, the communication manager **119**, as shown by blocks **152** and **158** of **FIG. 7**, communicates the retrieved GUI code **33** and status data **74** to the user client **52**, which displays a GUI **101** based on the GUI code **33**. The displayed GUI **101**, which will be referred to hereafter as the "original GUI **101**," may include the status data **74** transmitted along with the GUI code **33**.

While the user is viewing the original GUI **101**, the status manager **115** is periodically checking the status of each element **21** that is of interest to any of the clients **52**, as shown by block **161** of **FIG. 9**. Assume that, when checking the status of the particular element **21,** the status manager **115** discovers, in block **163**, that a change in the element's status has occurred. This may be achieved by polling the particular element **21** and comparing the polled data with the status data **74**. In such a case, the status manager **115** updates, in block **166**, the status data **74** for the detected change and then notifies the server **117** of the detected change, as shown by block **169**. In response, the server **117** passes, to the communication manager **119**, a transmission request for notifying each interested client **52** of the detected change, as shown by blocks **172** and **176** of **FIG. 8**. In response, the communication manager **119**, in block **158** of **FIG. 7** and based on the client profile data **105**, determines which clients **52** are interested in the particular element **21** and then transmits a message indicative of the occurrence of the detected status change to each such client **52**. Each such client **52** then updates its displayed data, as appropriate, to reflect the detected status change.

After viewing the status data **74** of the particular element **21**, the user of the user client **52** may decide to change the configuration of the particular element **21** and provide one or more inputs to the user client **52** for doing so. In response, the user client **52** transmits, to the EMS **50**, a command or request for changing the configuration of the particular element **21**. The communication manager **119** receives the change request and notifies the server **117** of the change request, as shown by blocks **177** and **179** of **FIG. 7**.

In response, the server **117** instructs the status manager **115** to service the change request, as shown by blocks **184** and **187** of **FIG 8**. The status manager **115** then changes

the configuration of the particular element **21** according to the change request, as shown by blocks **192** and **194** of **FIG. 9**. In block **197**, the status manger **115** updates the element status data **74** to reflect the configuration change. Once the configuration change is effectuated by the status manager **115**, the status manager **115** informs, in block **169**, the server **115** that the state or status of the particular element **21** has been changed. Accordingly, the server **117** passes, in block **176** of **FIG 8**, a transmission request to the communication manager **119** instructing the manager **119** to inform each client **52** interested in the particular element **21** of the status change. The communication manager **119** then notifies each such client **52** of the status change in block **158** of **FIG. 7**.

At some point, a user may modify, add, or otherwise update the GUI code **33** at the EMS **50**. The server **117** preferably detects such a change in block **201** of **FIG. 8**. If the change to the GUI code **33** is an update to a set of code **33** previously utilized by the EMS **50**, then it is possible that some of the clients **52** are running GUI code **33** that should be updated by the foregoing change. Thus, in such a case, the server **117** preferably passes, to the communication manager **119**, a transmission request for notifying such clients **52** of the GUI code change, as shown by block **204**. The communication manager **119** then notifies each such client **52** of the change thereby enabling the clients **52** to update their displays based on the aforementioned change to the GUI code **33** of EMS **50**. Note that the communication manager **119** may identify each client **52** that should receive the notification based on the client profile data **105**. In this regard, each client **52** interested in an element **21** of the type associated with the updated GUI code **33** is preferably notified.

When the user no longer desires to monitor the status of the particular element **21** or to change the configuration of the particular element **21**, the user may submit an input, via input device **93** of the user client **52**, for closing the original GUI **101**. In response, the user client **52** closes the original GUI **101** and discards the GUI code **33** defining the closed GUI **101**. The client **52** also transmits, to the EMS **50**, a termination message indicating that the user has closed the GUI **101** associated with the particular element **21**. As shown by blocks **211** and **214** of **FIG. 7**, the communication manager **119** receives this message and updates the client profile data **105** to indicate that the client **52** is not interested in the particular element **21**.

It should be emphasized that the above-described embodiments of the present invention, particularly, any "preferred" embodiments, are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the invention. Many variations and modifications may be made to the above-described embodiment(s) of the invention without departing substantially from the spirit and principles of the invention. All such modifications and variations are intended to be included herein within the scope of this disclosure and the present invention and protected by the following claims.